

National Institute of Standards and Technology:

Where World Class Science & Engineering
Meet Real World Needs

Willie E. May, Under Secretary of Commerce for Standards
and Technology and NIST Director

President's Council of Advisors on Science and Technology

Sept. 20, 2015

Topics

- NIST Mission and Overview
- Evolution of NIST Programs and *Activities in support of Mission*
- Examples of Current Activities Addressing Contemporary Societal Needs



Worked at every level within NBS/NIST (971- present)

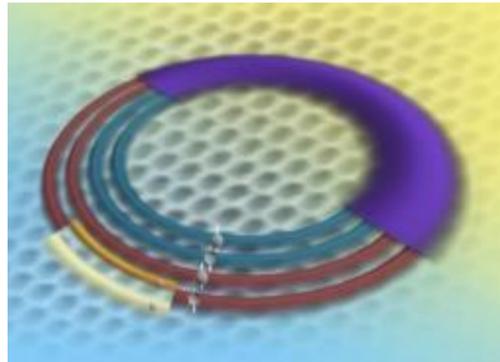
- Bench Chemist
- Project Leader
- Group Leader
- Analytical Chemistry Division Chief
- Chemical Science and Technology Laboratory Director
- Material Measurement Laboratory Director
- Associate Director for Laboratory Programs
- Acting Under Secretary for Standards and Technology and NIST Director
- Under Secretary for Standards and Technology and NIST Director



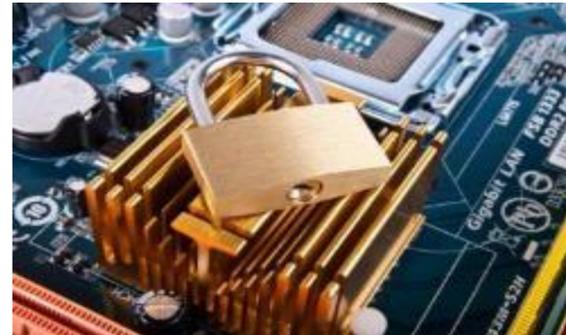
NIST's Mission is to:

promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

- **The development and maintenance of standards** provides the first and primary reason for NIST's existence. This standards work must keep abreast with the expansion of the frontiers of science”
- **Our deep and broad research expertise and competencies** support expanding standard needs as well as technological innovation – e.g., new materials, advanced clinical diagnostics and therapies, advanced communications, etc.



Nanomanufacturing: New measurement tools for advanced materials manufacturing



Cybersecurity: Improved response to cyber threats



Advanced Communications: Testbeds, quality control, interoperability for next-generation communications

- **Our non-regulatory status** enables our important role as a convener to facilitate collaborations between industry and government

Who We are and What We Do



World Leading
Scientific and
Engineering Research



Nationwide Network of
Manufacturing
Extension Centers



Program in
Performance
Excellence



Advanced Manufacturing
National Program Office

NIST: A Premier Scientific Institution

A world-leading measurement science and standards program with world-class staff!



Debbie Jin

*2003 MacArthur Fellow
2013 L'Oreal/UNESCO "For Women in Science" award
2014 Isaac Newton Medal*

- Work resulting in 4 + 1 Nobel Prizes since 1997
- Kyoto Prize winner in 2011
- 2 MacArthur Fellowship winners since 2003
- National Medal of Science winners in 1998 and 2007
- Isaac Newton Medal in 2014
- ~ 10 National Academy Members
- ~120 National Society Fellows
- ~60 National/International Awards/yr



Dan Madrzykowski
2013 Service to America Award



Ana Maria Rey
2013 MacArthur Fellow



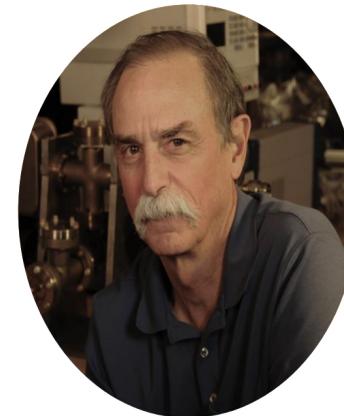
Bill Phillips
1997 Nobel Prize in Physics



Eric Cornell
2001 Nobel Prize in Physics



John Hall
2005 Nobel Prize in Physics



David Wineland
*2010 Nobel Prize
2007 National Medal of Science*



John Cahn
1997 National Medal of Science and 2011 Kyoto Prize in Materials Science



Dan Shechtman
*2011 Nobel Prize in Chemistry
based on work while Visiting Scientist at NIST*

NIST AT A GLANCE

Major Assets, Partnerships, People, Budget



2 Large Research Campuses

Gaithersburg, MD— **62** bldgs. **578** acres
Boulder, CO—**26** bldgs., **208** acres



Partnerships In Every State

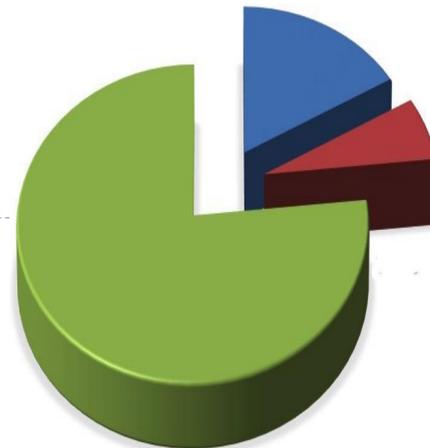


~**400** Manufacturing Extension Locations
10 joint institutes & Centers of Excellence



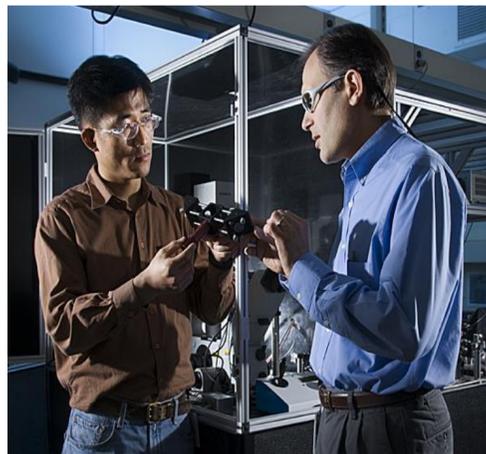
FY 2015 Appropriations. \$864 Million

NIST labs, **\$675.5 M**
Industrial Technology Services, **\$138.1 M**
Construction of Research Facilities, **\$50.3 M**



Additional Resources

~ **\$120 M** from other government agencies
~ **\$50 M** from reimbursable services



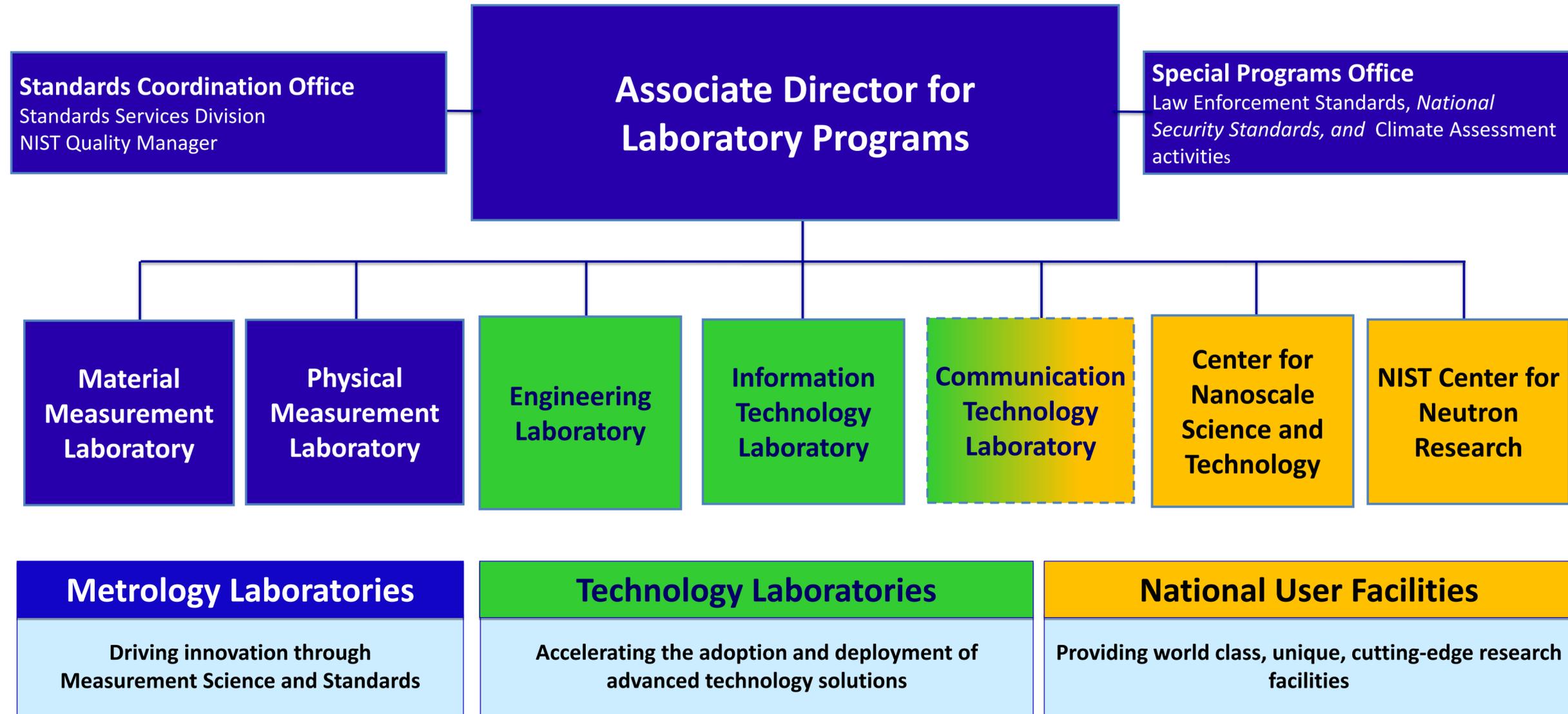
People Employees & Associates



~**3,000** Employees
~**3,500** Guest Researchers and other NIST Associates
~**400** NIST Staff on ~ **1,000** standards committees

NIST Laboratory Program

providing measurement solutions for industry and the nation

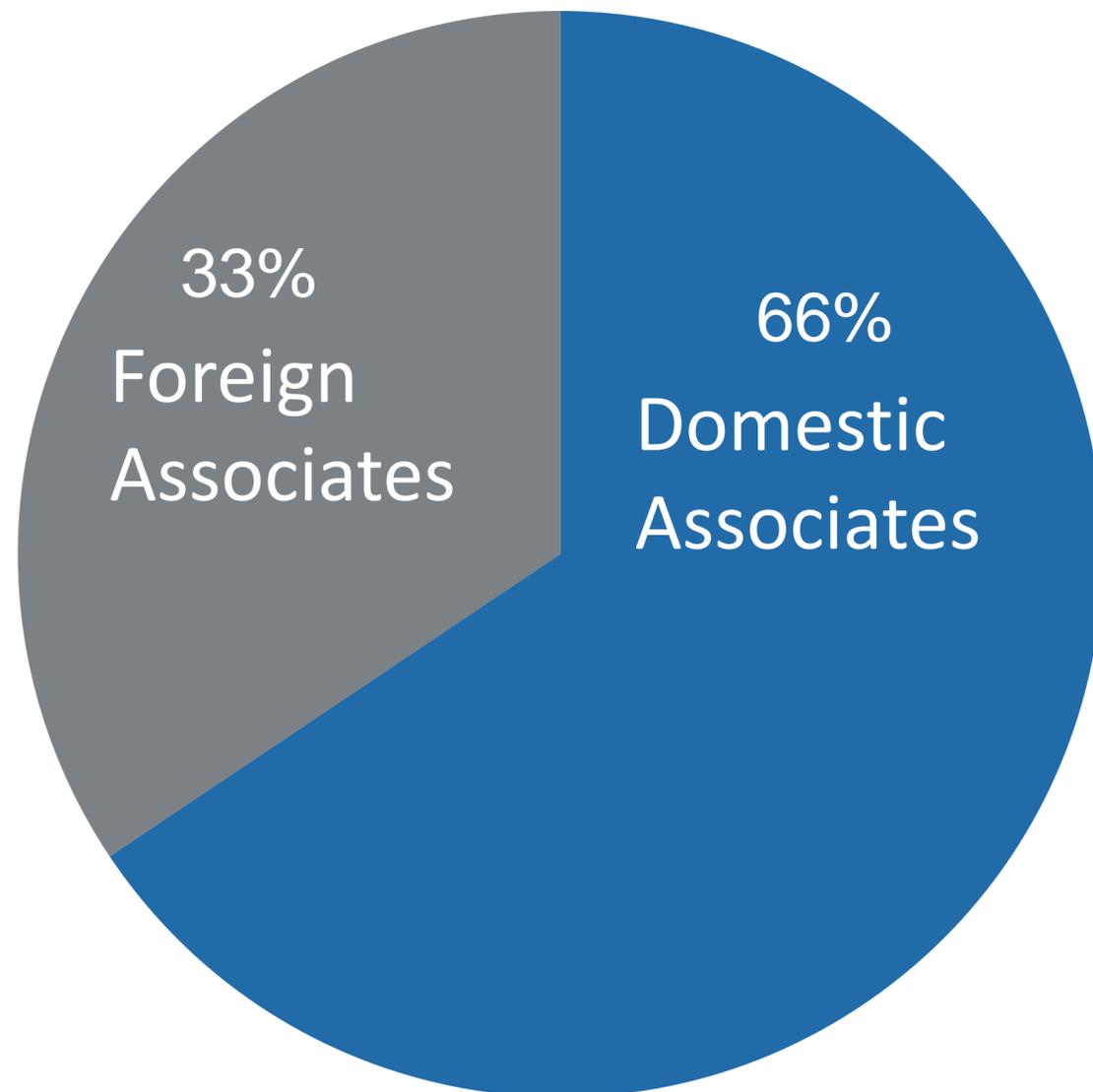


NIST Lab Resources for FY15

- ~ \$676 million from Direct Appropriations
- ~ \$120 million from Other Federal and State Agencies
- ~ \$50 million for other reimbursable services

NIST Associates

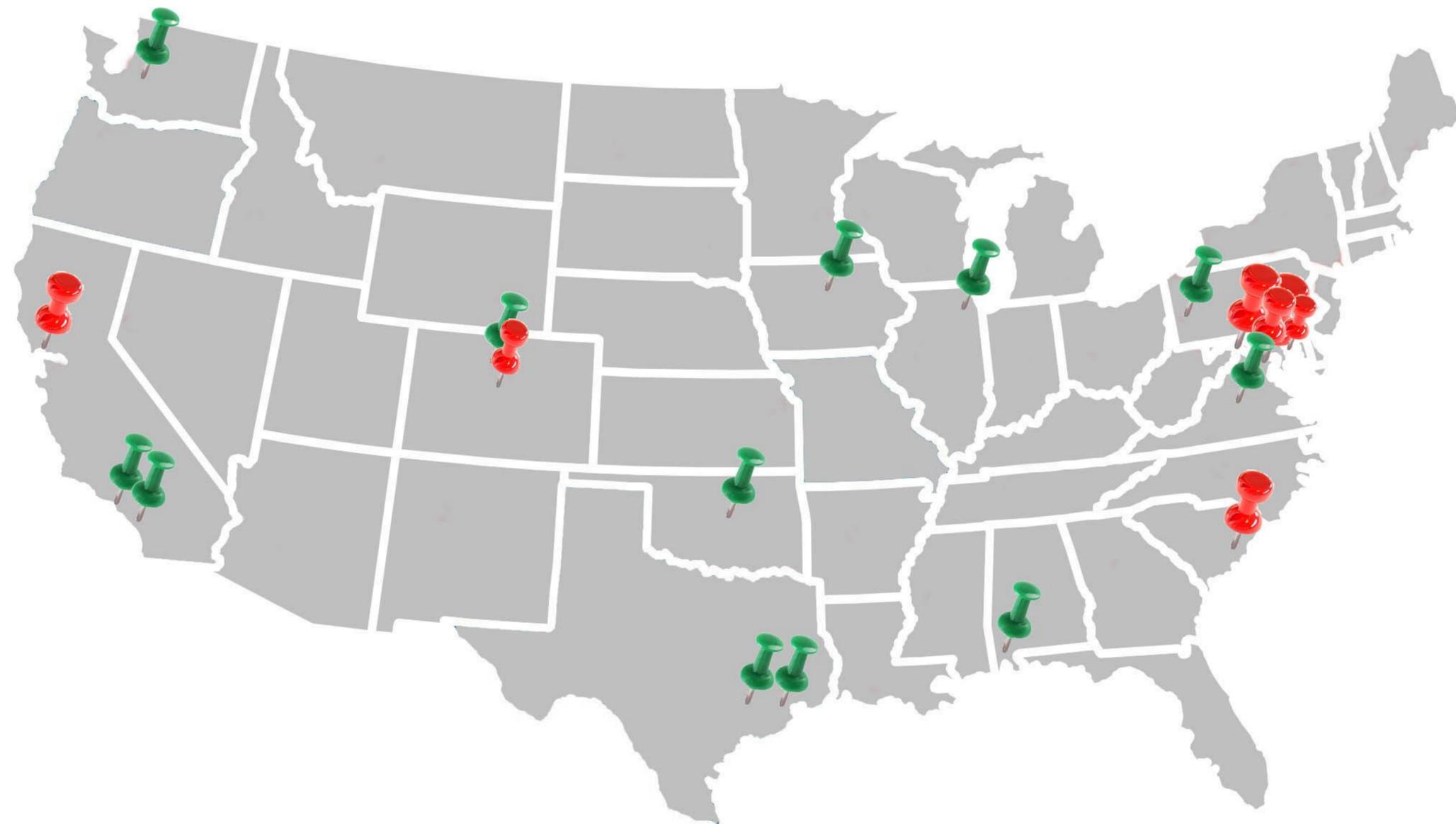
More than doubling our research talent through on-campus research collaborations



DOMESTIC		2300
Academia	1649	
Industry Total	712	
<i>Small Businesses</i>	558	
<i>Large Businesses</i>	154	
Other Agency	367	
FOREIGN		1206
Academia	364	
Industry	17	
Government (including NMIs)	80	
Total for FY2014		3506

Joint Institutes and Centers of Excellence

Leveraging the nation's best experts in a range of S&T fields



Joint Institutes/Centers (red)

- JILA –CO
- Institute for Bioscience and Biotechnology Research—MD
- Hollings Marine Laboratory—SC
- Joint Quantum Institute, Joint Center for Quantum Information and Computer Science—MD
- National Cybersecurity Center of Excellence—MD
- Joint Institute for Metrology in Biology—CA

NIST Centers of Excellence (green)

- Center for Hierarchical Materials Design (advanced matls.)—IL
- Center of Excellence in Forensic Science –IA, PA, VA, CA
- Community Resilience Center of Excellence –CO, OK, TX, WA, AL, CA

New NIST “Centers of Excellence”

Leveraging the nation’s best experts in important S&T fields

Center for Hierarchical Materials Design (CHiMaD,

advanced mats. established Dec. 2013)

- University of Chicago
- Northwestern -Argonne Inst. of Science and Engineering
- Computation Institute
- In collaboration with QuesTek

Center of Excellence in Forensic Science

(established May 2015)

- Iowa State University (Ames)
- Carnegie Mellon University
- University of Virginia (Charlottesville)
- University of California, Irvine

Community Resilience Center of Excellence

(established Feb. 2015)

- Colorado State University
- University of Washington
- University of South Alabama
- Rice University
- California Polytechnic University in Pomona
- Texas A&M University

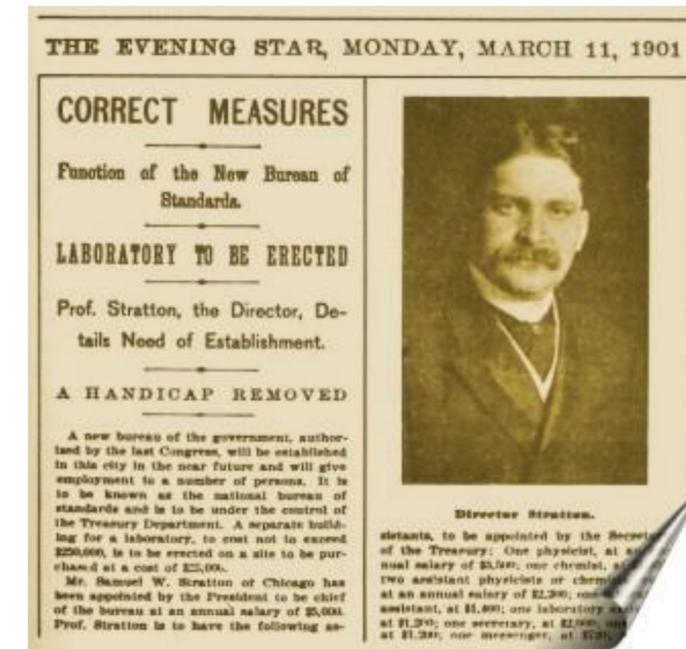


NIST (NBS) established in 1901

“It is therefore the unanimous opinion of your committee that no more essential aid could be given to

- manufacturing
- commerce
- the makers of scientific apparatus
- the scientific work of Government
- schools, colleges, and universities

than by the establishment of the institution proposed in this bill.”



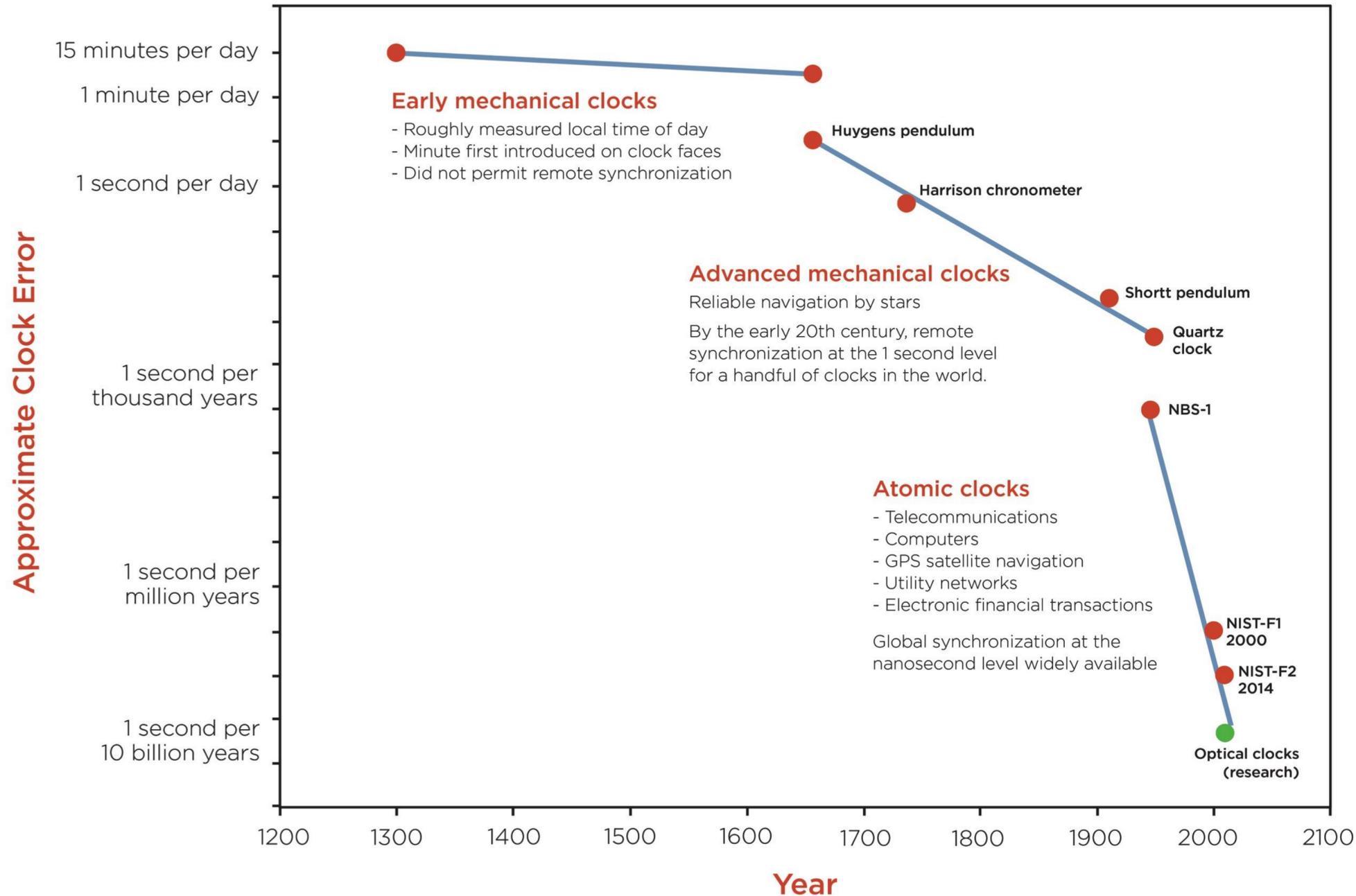
*House Committee on Coinage, Weights and Measures ... on the establishment of the **National Bureau of Standards (now NIST)** May 3, 1900*

Organic Act of 1901; Updated in 2008

Functions and activities of the Institute include:

- custody and dissemination of national standards
 - comparison of US national standards with those of other nations
- determination of physical constants and the properties of materials,
- solutions to measurement and standards problems of other government agencies
- providing (Innovation) assistance to industry

Leading the world in defining the international system of units



TIME

Record-setting Atomic Clock

NIST/JILA's strontium lattice atomic clock, accurate to:

- 1 second in 15 billion years

Why Precision Matters

Precision required for:

Power grid, telecom, and computer networks:

- 1 millionth of a second per day

GPS System:

- 1 billionth of second per day

Financial markets

- Time stamp hundreds of billions of dollars in transactions a day

Leading the world in redefining the international system of units



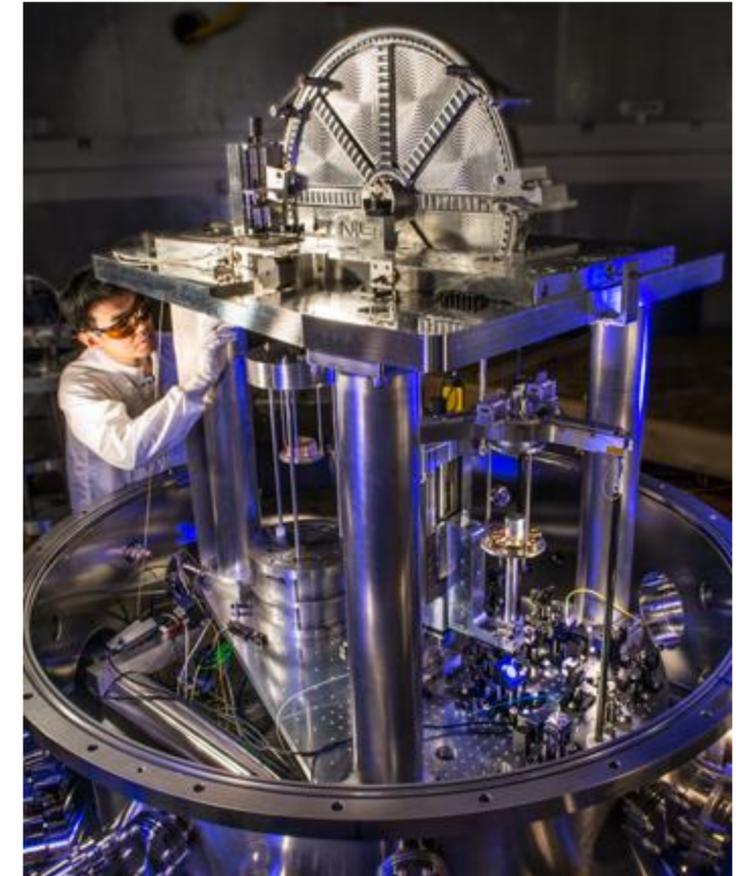
Physical kilogram artifact (1889)

MASS



Redefining mass from a physical artifact to a constant of nature by 2018.

Working with other national metrology institutes around the world, NIST researchers are carefully measuring **Planck's constant** so that it can be the cornerstone of a new, improved International System of Units.

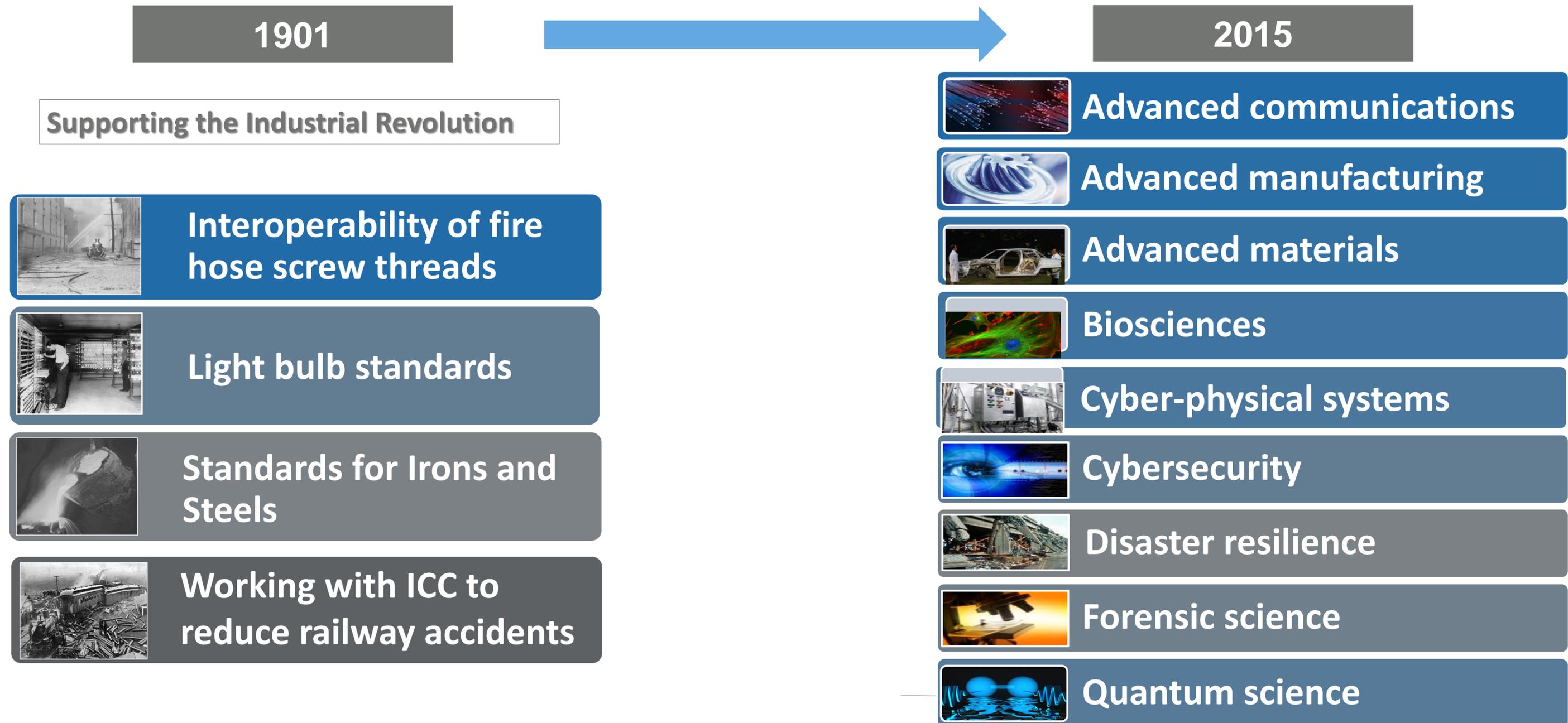


Electronic kilogram (2018)



Int. Avogadro Project

Since our inception as NBS, in addition to maintaining the more traditional National Physical Measurement Standards, we have also focused a significant portion of our research and measurement services activities on addressing contemporary societal needs.



Advanced Manufacturing

Building a National Network for Manufacturing Innovation

Current Institutes (all led by DoD and DoE)

- America Makes (additive manufacturing)
Youngstown, OH
- Digital Manufacturing and Design
Innovation Institute, Chicago, IL
- Lightweight Innovations for Tomorrow,
Detroit, MI
- Power America (Wide Band Gap
Semiconductors) Raleigh, N.C.
- Institute for Advanced Composites
Manufacturing Innovation, Knoxville, TN
- Integrated Photonics, New York
- Flexible Hybrid Electronics, San Jose, CA

Coming Soon

- Clean Energy/Smart Manufacturing
- Revolutionary Fibers and Textiles,

Today, I'm asking Congress to build on the bipartisan support for this idea . . . creating a network of these hubs and guaranteeing that the next revolution in manufacturing is "Made in America." --July 30, 2013



NIST Role in NNMI

- **Hosts the Advanced Manufacturing National Program Office that**
 - coordinates collaborations among Institutes
 - Provides annual reporting to Congress
 - Shares best practices among Institutes
 - Establishes new Institutes that address private sector needs
- **Providing \$11 M split among three of the current institutes to support measurement science research**
- **NIST lab experts are heavily involved in advisory roles and collaborations with Institute researchers**

NIST Programs for Manufacturing

Supporting Innovation from Small Businesses to Multinational Firms

Industry Services

- Hollings Manufacturing Ext. Partnership (MEP) – nationwide network
- Advanced Manufacturing Technology Consortia – grants to industry consortia to identify critical gaps in technology

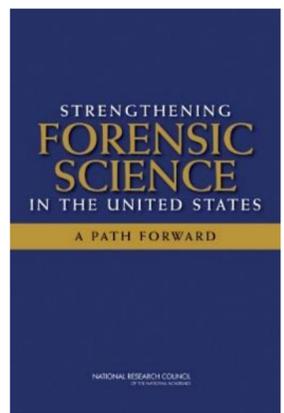
Advanced manufacturing research in NIST Labs

- Advanced Materials
- Smart manufacturing
- 3D Printing/Additive Manufacturing
- Lightweighting
- Nanomanufacturing
- Synthetic Biology/Biomanufacturing
- Digital thread (many other fields)



Strengthening the Science in Forensic Science

Responding to Landmark 2009 National Academies Report



National Commission on Forensic Science

- Co-chaired by DOJ and NIST
- Helps improve forensic data/information
- Develops policy recommendations for U.S. Attorney General
- 32 voting and 8 ex-officio members
- Forensic science practitioners, academic researchers, prosecutors, defense attorneys, judges, other stakeholders



Sally Q. Yates
Deputy Attorney General
Co-Chair



Nelson A. Santos
Vice-Chair (DOJ)



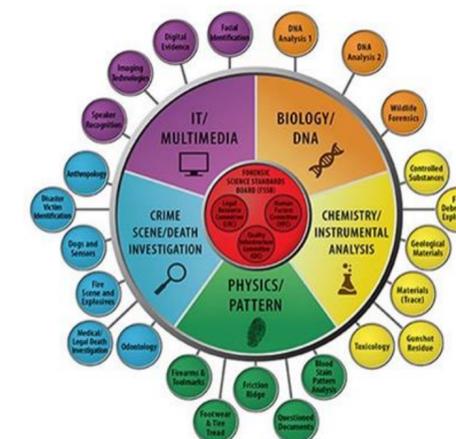
Willie E. May
NIST Director
Co-Chair



John M. Butler
Vice-Chair (NIST)

Organization of Scientific Area Committees (OSAC)

- 29 Committees and subcommittees
- More than 500 committees members, wide array of expertise
- Develop and disseminate consensus documentary standards and guidelines
- 5 major topic areas: Biology/DNA, Chemistry, Crime Scene/Death Investigation, Digital/Multimedia, Physics/Pattern Interpretation



Strengthening Forensic Science

Establishing science-based methods since 1913

Forensic Research in NIST Labs today

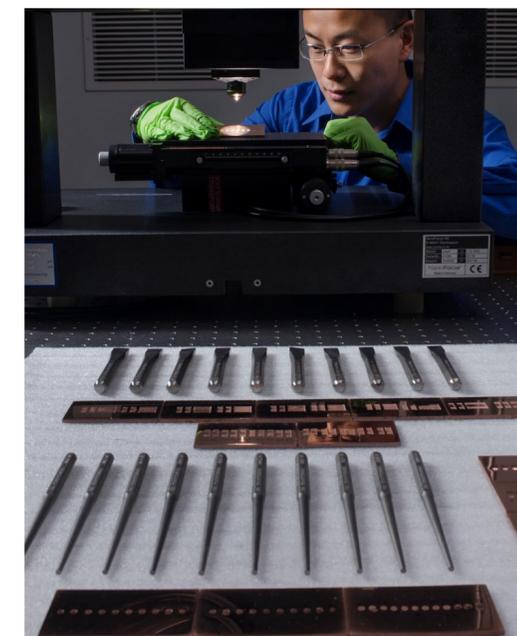
Forensic Genetics	Increased reliability of analysis of DNA samples.
Ballistics and Associated Tool Marks	An objective, numerical and statistically valid criteria for identification of firearm and tool mark evidence
Digital and Identification Forensics	Reference data for personal computer software through the National Software Reference Library (NSRL) and the Computer Forensic Tool Testing (CFTT) program. Support for the FBI fingerprint database,
Statistics	A long term program to build new methods suited to forensic problems in the specific use cases such as illicit drug analysis, pattern recognition, and trace evidence analysis
Toxins	Designer drugs, synthetic marijuana, and ricin are a few of the compounds requiring measurement research to establish validated analytical procedures.
Trace	Development of objective measures for interpretation of evidence to promote standardization of trace evidence work across laboratories.

Recent Accomplishments

- New computer-based correlation methods for ballistics matching
- Quantified differences in results among laboratories for mixed DNA samples
- Hosted major international conference: “Error Management in Forensic Science” in July 2015



Wilmer Souder, NIST forensic science pioneer



Strengthening Forensic Science

NIST's New Forensic Science Center of Excellence

NIST funding of \$20M over 5 years

Goals:

- improve the statistical foundation for pattern evidence (fingerprints, firearms, tool marks, etc.) and digital evidence (computer, video, and audio analyses)
- develop education and training on probabilistic methods for practitioners and other relevant stakeholders

Awardees:

Consortium led by **Iowa State** involving Carnegie Mellon, University of California-Irvine, and the University of Virginia



Advanced Communications

Established NIST Communications Technology Laboratory (CTL)

The CTL promotes the development and deployment of advanced communications technologies through the conduct of leading edge R&D on both the metrology and understanding of physical phenomena, materials capabilities, complex systems relevant to advanced communications; and through the conduct of research targeted at supporting a multi-level testbed facility.

Initial Areas of Focus of CTL:

- **Public Safety Communications Research (PSCR)** – Increase PSCR technical staff and enhance the LTE laboratory infrastructure to increase support for public safety communications.
- **Spectrum Sharing** – Develop spectrum sharing metrology, and work through the joint NTIA/NIST Center for Advanced Communications, and the National Advanced Spectrum and Communications Test Network, to create a trusted capability to facilitate spectrum sharing studies, optimize access to engineering capabilities, and engage spectrum users in collaborations.
- **Develop R&D programs-** Work with stakeholders to develop an aggressive R&D program to address longer-term needs, e.g., leading U.S. Government efforts in 5G.

- **The Middle Class Tax Relief and Job Creation Act of 2012 created the First Responder Network Authority (FirstNet)** as an independent entity within the Department of Commerce to provide emergency responders with the first U.S. nationwide, high-speed, broadband network dedicated to public safety.
- **NIST CTL gets \$300M to provide the R&D and testing support for FirstNet.**



Quantum Research at NIST

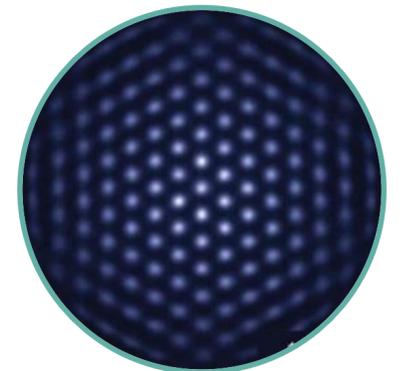
Ensuring U.S. Leadership in Quantum Information Science

- 100X Performance Increase in NIST atomic clocks during the past decade thanks to quantum technology
- 4 Nobel Prizes in the past 18 years



Program Goals

- Engineer robust quantum systems for improved sensing and better quantum standards
- Create, develop and characterize robust and efficient hybrid quantum systems
- Develop tools for the understanding, manipulation, and control of complex quantum systems
- Develop and explore quantum materials and solid state qubits for future quantum devices



NIST Cybersecurity Program

Conduct research; develop and deploy information security standards and technology

Improving the cybersecurity infrastructure

- Provide information on vulnerabilities, impact measurements, detection techniques

Supporting national priorities and stakeholders

- Secure online transactions, health IT, smart grid, voting
- Federal agencies, CIO council, industry

Cybersecurity research and standards

- Network security, biometrics, product assurance, metrics, cryptography, usability

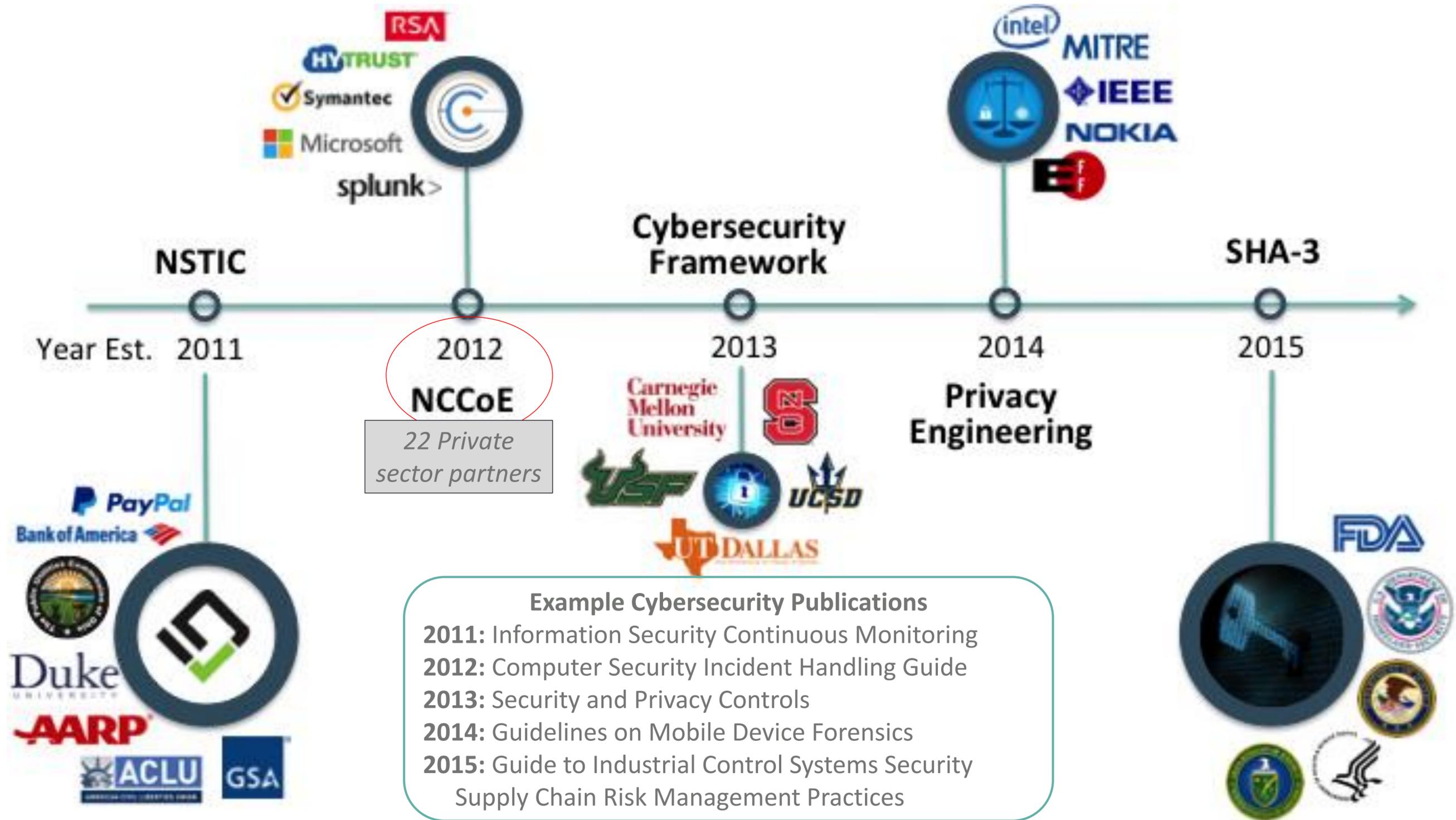
National Initiative for Cybersecurity Education

Validated over 3200 cryptographic modules used in range of applications: weapon systems to everyday consumer electronics

Over 4 million secure credentials issued to federal employees and contractors based on NIST standards

Developed Cybersecurity Workforce Framework

Major NIST Cybersecurity Initiatives and Stakeholders



Global Cities Team Challenge

Challenging teams of cities to work with innovators to develop, deploy, and evaluate standards-based Smart Cities technologies

Facilitate partnerships among cities/communities and innovators

- Show the impact of replicable and scalable Smart City projects

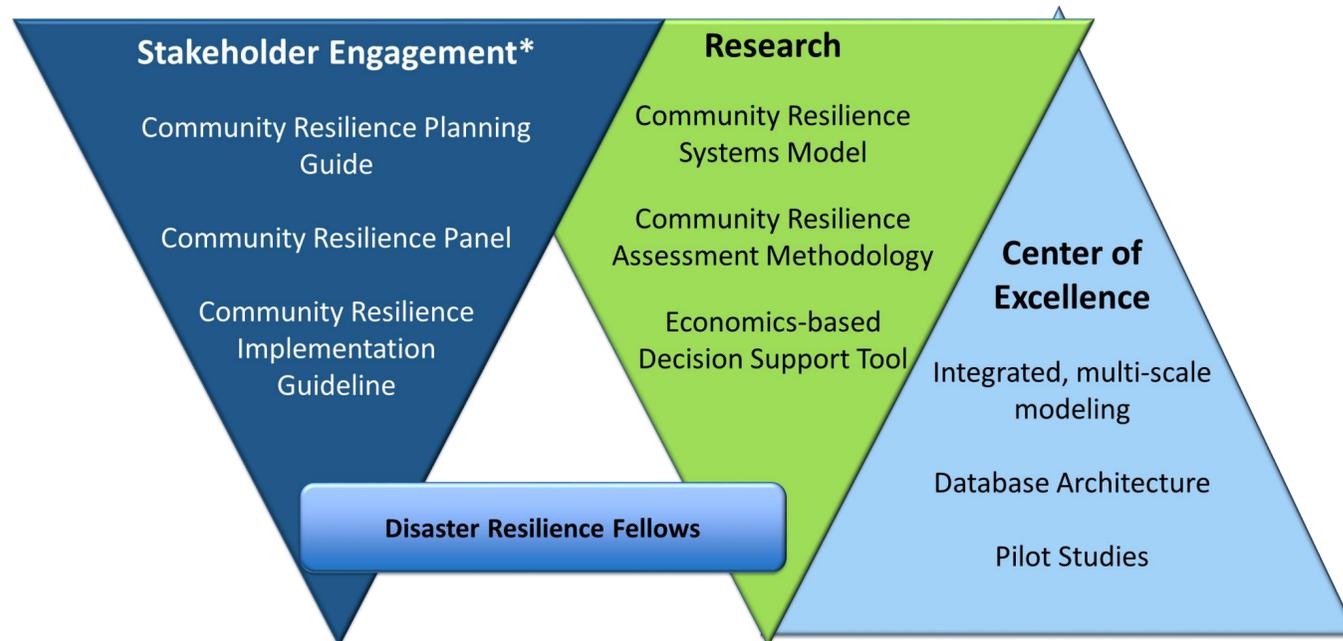
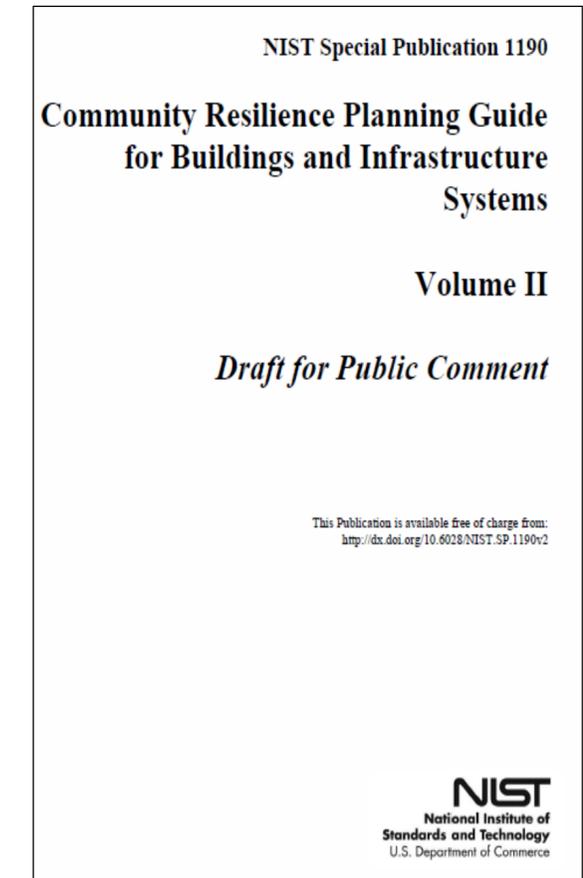
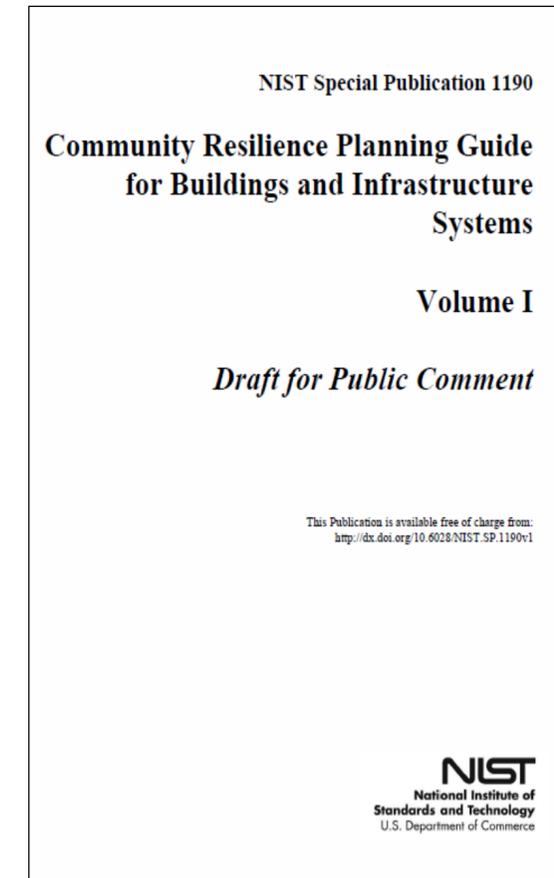
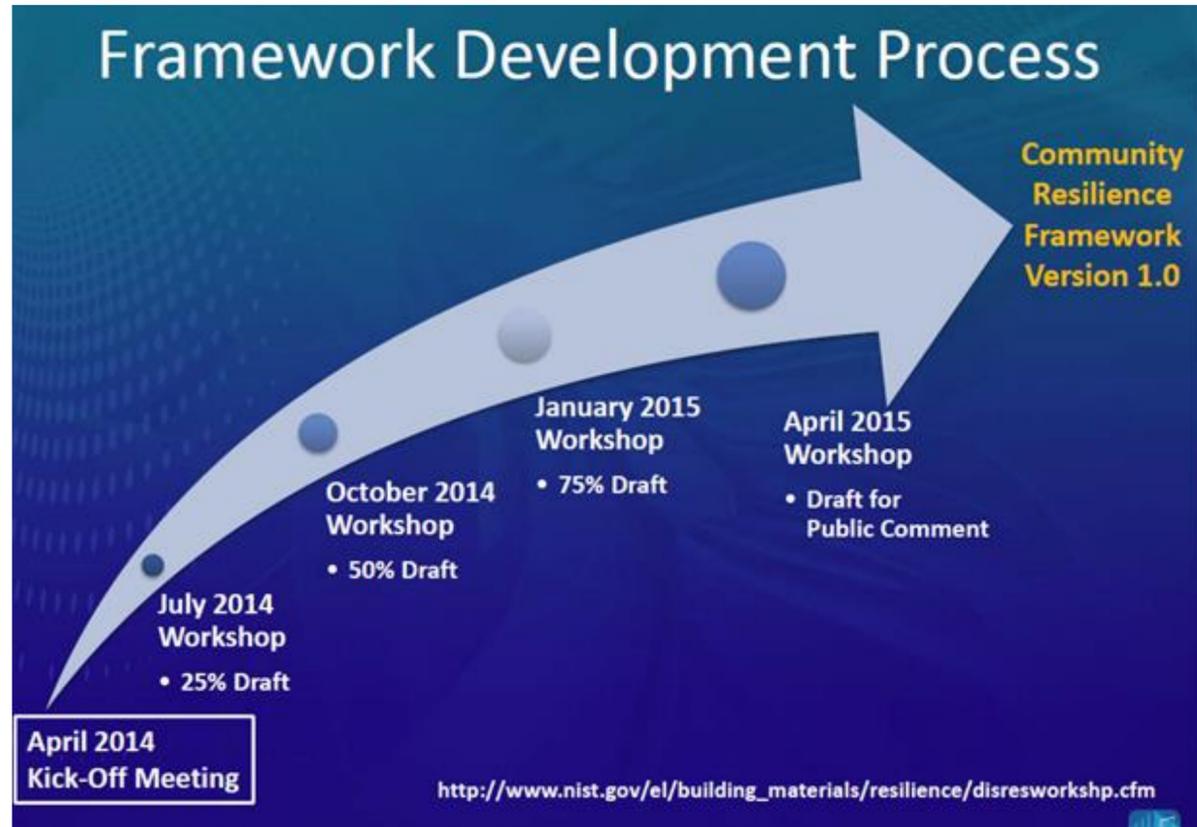
Global Cities Team Challenge Expo on June 1 at the National Building Museum in Washington DC

- 64 teams exhibited and presented in partnership with 50+ municipal governments around the world
- 200+ organizations
- 1200+ attendees, 50+ world-wide media outlets



Launching Next Round of Global Cities Team Challenge

NIST Community Resilience Program



*Stakeholder Engagement component is called out in the President's Climate Action Plan

Bioprogram growth through strategic partnerships

Institute for Bioscience and Biotechnology Research (IBBR) Partnership with University of Maryland System



Precision biomolecular structure/function measurements & standards to support biopharma and biotechnology

- NIST focus area: Biomanufacturing
- Funding: Grant to UMD (\$2.2M/annual) for infrastructure, operations, scientific programs
- IBBR NIST Staff, Associates and Affiliates (~ 50)

Joint Initiative in Measuring Biology (JIMB) Partnership with Stanford University



Measurements, standards and informatics tools for the genomics and the emerging synthetic biology enterprise.

- NIST focus areas: Genomics, Synthetic Biology
- Funding: Grants to Stanford (~2M) for research, training, seed funding for metrology
- JIMB NIST Staff: 11

NIST labs reminded me of one of my favorite places, a hardware store, where I'm fascinated with all of the small objects in the bins and wonder what they are used for. NIST's bins are no secret to chemists, physicists, and engineers, but there hasn't been much for biologists. But now biologists have a bin or two at NIST...

The great news for us is that NIST has decided to help...by developing standards we can all use as benchmarks for our research and clinical applications. But they won't make a big deal of it; NIST does their work quietly -- choosing projects not on the basis of headline-grabbing potential, but on the potential to improve the quality of our science.

Jeanne P. Loring, Ph.D., Scripps Research Institute
Member, NRC Review Panel

Thank You for Your Attention

Questions / Discussion ?



Gaithersburg, MD
62 buildings; 578 acra



Boulder, CO
26 buildings; 208 acra